Leveraging External Hazard Data to Safeguard Automated Driving Systems (ADS)

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Introduction

External hazard data contains safety-relevant information. There is a need to develop strategies that can effectively utilize these information to enhance the ADS safety.

In this study, we address how external hazard data, despite their potential unreliability, can improve ADS behavior. We propose the Early Hazard Process System (EHPS), which aims to process external hazard information and send it to ADS (see Fig 1).

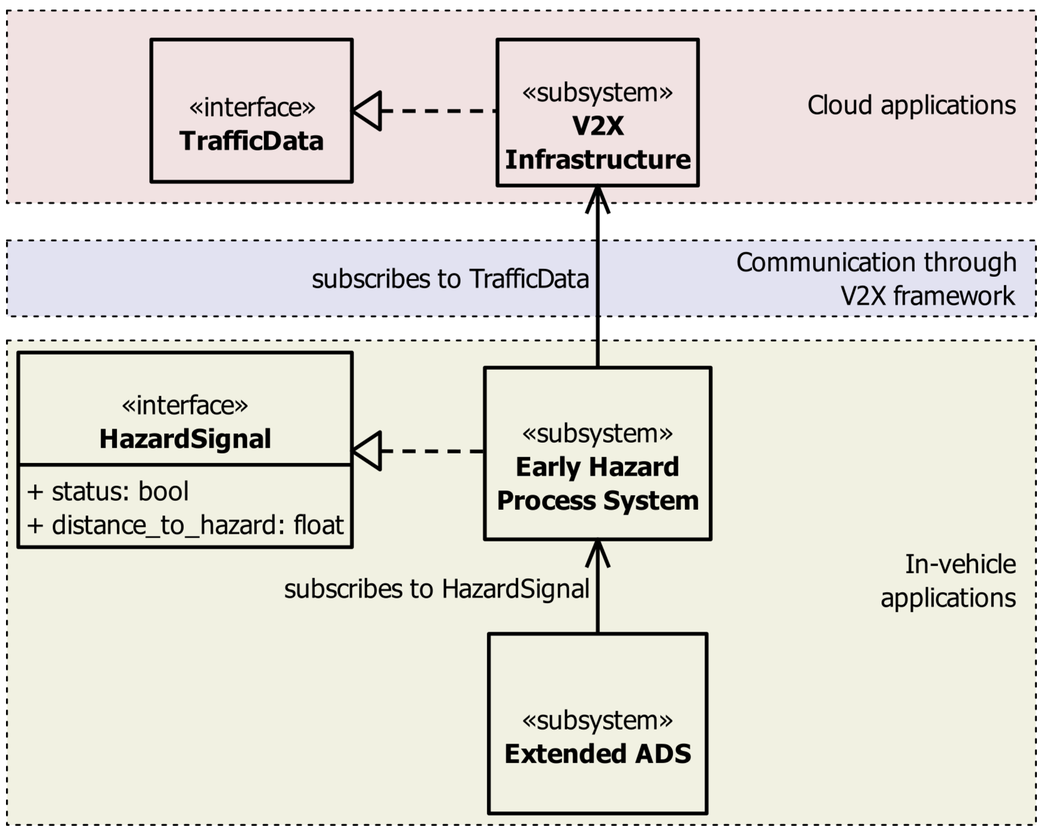

Fig. 1. Schematic view of the subsystems considered in this study and their interfaces.

The ADS uses the HazardSignal to adapt its behavior in response to potential hazards ahead. In this regard, the ADS needs an extension, in order to achieve that goal. We propose a minimal extension represented as a three-state model formalized by a state machine (see Fig 2).

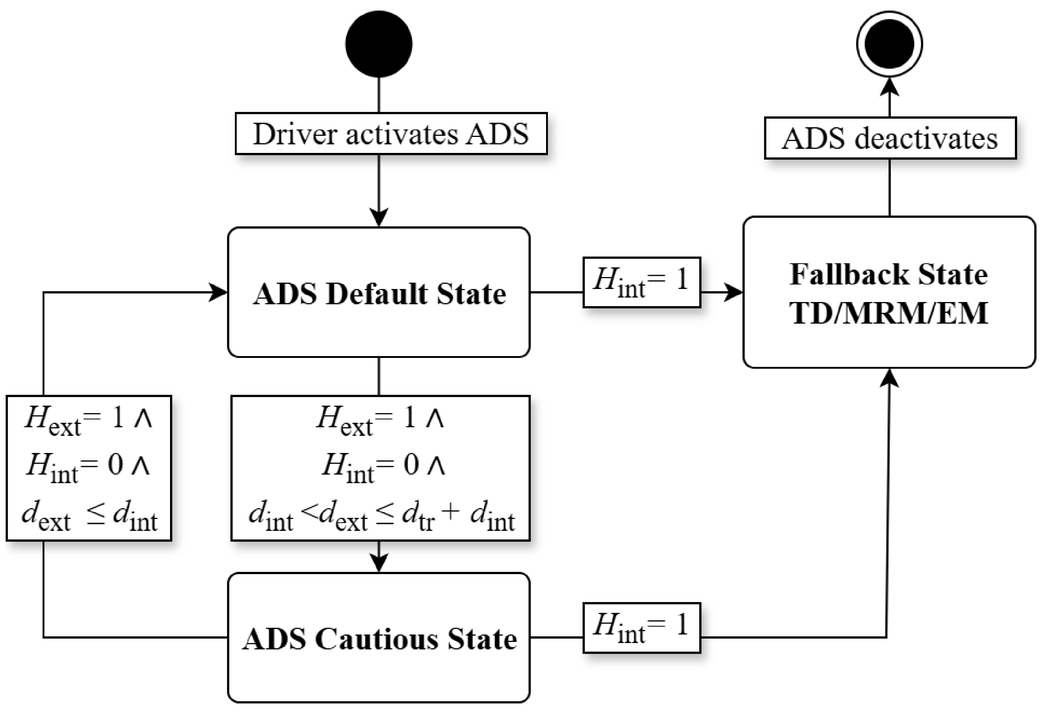

Fig. 2. The state machine model of extended ADS with three states and transitions between states.

Results

Simulation results show an increase in the time-to-collision (TTC) compared to baseline by 45% and reduce in the average required deceleration by 61.7%. Even when the external hazard data are unreliable, our proposed model still improves TTC by 20.3% and lowers the required deceleration by 40.8% (see above table).

System under test	TTC [s] +/- std	Required Deceleration [m/s²] +/- std
Normal ADS	3.102 +/- 0.021	3.306 +/- 0.032
Proposed ADS when using reliable data	4.497 +/- 0.018	1.267 +/- 0.001
Proposed ADS when using unreliable data	3.730 +/- 0.001	1.957 +/- 0.009

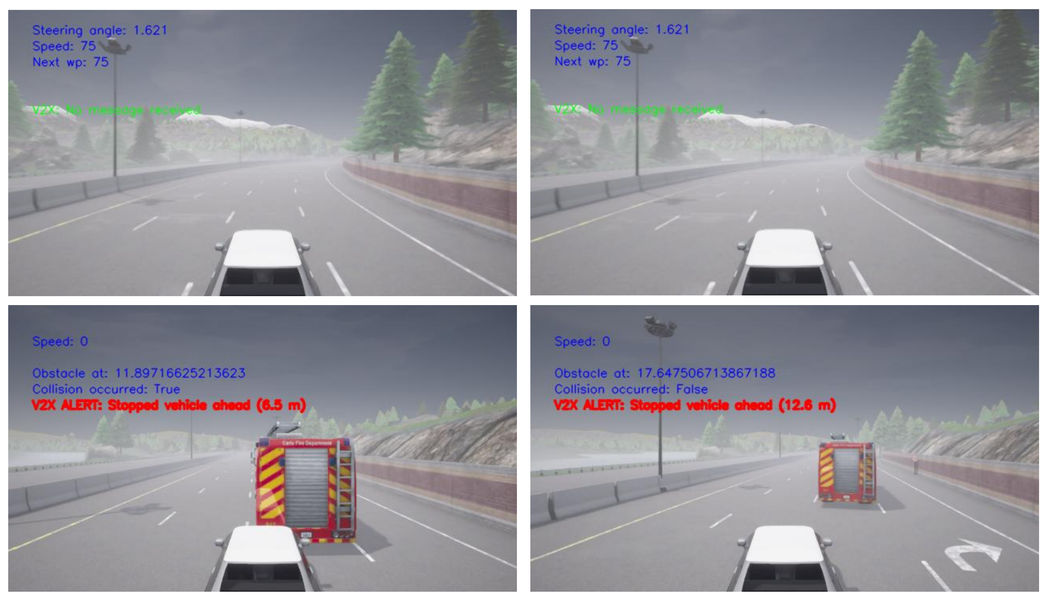

Fig 3. ADS using external hazard data (right) stops earlier before hazard compared to ADS that relies on onboard sensors (left).

Safety argumentation

When data is fully reliable it is easy to show the proposed system in Fig 2 is as safe as normal ADS. We considered other cases where unreliability in external hazard data could lead to secondary hazards themselves. For example:

- hazard does not exist but is reported by EHPS,
- hazard exists but is not reported by EHPS,
- hazard is closer to ADS than is reported by EHPS,
- hazard is farther to ADS than is reported by EHPS.

In the paper we show that in all cases the proposed ADS performs at least as safely as the baseline ADS (see paper for more details.

Link to recorded video and demonstration

Here we will have a QR code to our recorded video.